THERMODYNAMICS

Thermodynamics is the branch of Physics which deals with the study of flow or transformation of heat or any other form of energy.

Thermodynamic State :- The state of thermodynamics System is determined in terms of four variables which are k/a thermodynamic Variable

(1) mass (M)
(2) Pressure (P)
(3) Volume (V)
(4) Temperature (T)

A set of Particular values of M, P, V, & T define a particular state of the System.

Thermodynamic Process.

(1) Isothermal Process :- In this process ΔT or $dT = 0$ (T is constant)

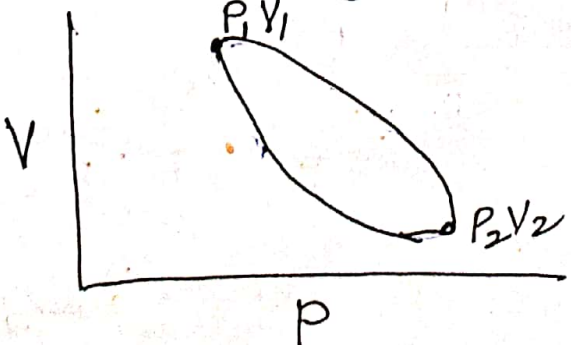
(2) Isochoric Process :- In this process Volume is const i.e ΔV or $dV = 0$

(3) Isobaric Process :- In this Process Pressure P is constant ie ΔP or $dP = 0$

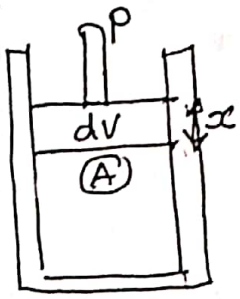
(4) Adiabatic Process :- No exchange of energy between System & surrounding.

P V T → all variable & entropy constant

(5) cyclic process :- If the initial and the final state of a system are same then the process is called cyclic.



Workdone in thermodynamic Process.



Let us consider a gas in a cylinder of Area 'A' & volume V at Press P. The Workdone for displacement of Piston P

$$W = F \cdot dx$$
$$= P \cdot A\,dx$$
$$= P \cdot dV$$

$P = F/A$

$F = PA$

[A] Work done in Isochoric Process:- In Isocoric Process the volume of the gas is ~~expand~~ constant

$$\therefore dV = 0$$
$$\& \quad W = 0$$

[B] Workdone in Isobaric Process:- In Isobaric Process the Pressure is constant.

If the volume of the gas is changed from V_1 to V_2 then

$$W = P\int_{V_1}^{V_2} dV = P\,[V_2 - V_1].$$

[C] Workdone in Isothermal process:- In this Process the ~~temp~~ (T) is constant. There is an exchange of heat between System & Surrounding.

Using gas Law, $PV = nRT$

$$P = \frac{nRT}{V}$$

If the Volume of the gas is changed from V_1 to V_2 & Pressure change from P_1 to P_2

$$W = \int_{V_1}^{V_2} P\,dV = \int_{V_1}^{V_2} nRT \cdot \frac{dV}{V}$$

$$= nRT\,[\text{Log}]_{V_1}^{V_2}$$

$$\boxed{W = nRT \text{ Log } V_2/V_1}$$

$$\because \frac{V_2}{V_1} = \frac{P_1}{P_2} \Rightarrow \boxed{W = nRT \text{ Log } P_1/P_2}$$

(4) Adiabatic change :- It is a fast process in which Pressure P, Volume V & temp(T) all are variable. In this system entropy is constant

In adiabatic Process.

$$PV^\gamma = \text{constant} \; ; \; \gamma = C_p/C_v$$

$$\text{or, } P = KV^{-\gamma} \qquad = \text{Adiabatic exponant}$$

Work done in adiabatic Process.

$$W = \int_{V_1}^{V_2} P\,dV = \int_{V_1}^{V_2} KV^{-\gamma}\,dV$$

$$= \frac{K}{1-\gamma}\left[V_1^{1-\gamma} - V_2^{1-\gamma}\right]$$

$$= \frac{KV_1^{-\gamma}\cdot V_1 - KV_2^{-\gamma}\cdot V_2}{1-\gamma}$$

$$\boxed{W = \frac{P_1V_1 - P_2V_2}{1-\gamma}}$$

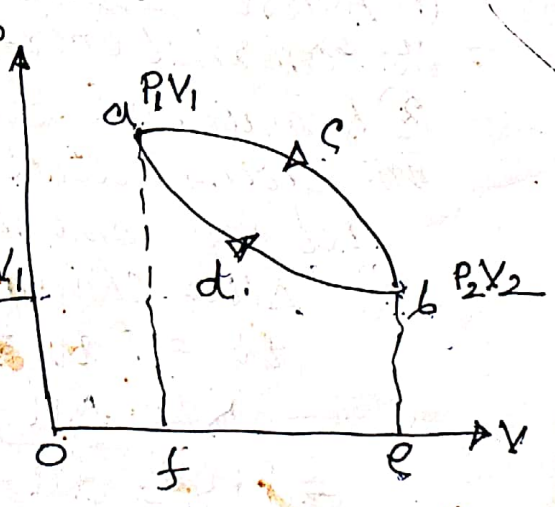
Interms of Temperature

$$\boxed{W = \frac{nR(T_1 - T_2)}{1-\gamma}}$$

(5) Workdone in a cyclic Process :-

Let us consider a cyclic Process abcd. Workdon in the Process.

$$W = \frac{P_1V_1 - P_2V_2}{1-\gamma} + \frac{P_2V_2 - P_1V_1}{1-\gamma}$$



= Area (acbefa) + Area (adbefa)

= Area (acbda)

W → +ve for clockwise cycle.

W → -ve for anticlockwise cycle.

INTERNAL ENERGY

The energy of a gas system due to the constituents & its configuration is called internal energy.

Internal energy = Internal K.E + Internal P.E + Rest mass energy.

$$U = K_i + V_i + m_0 c^2$$

For ideal gas, $V_i = 0$

$$\therefore U = K_i + m_0 c^2$$

If 'n' moles of ideal gas in equilibrium.

$$U = \frac{3}{2} nRT$$

Hence the internal energy depends upon its temp. If the temp is changed by T_1 to T_2 then the change in energy

$$\Delta U = \frac{3}{2} nR(T_2 - T_1).$$

FIRST LAW OF THERMODYNAMICS

According to first law of thermodynamics, 'HEAT Energy' given to a system is transformed almost in two forms.

(1) A first part of energy is used to increase the internal energy of the system

(2) Remaining part of the energy is used in doing work.

Let Q = Amount of heat given to a system

ΔU = change in internal energy.

$W = PdV$ = Workdone in this process.

$$Q = \Delta U + W.$$

$$\Rightarrow \boxed{dQ = dU + PdV} \quad \text{---(1)}$$

① In isochoric process, $dV = 0$

$\therefore \boxed{dU = dQ}$

or, $\boxed{dU = n C_V dT}$

Where C_V = Specific heat at constant volume.

② Isothermal Process :- In this process the temp of system remains constant i.e there is no change in internal energy.

$(dQ)_T = dW$

If state of system in isothermal charge, changes from P_1V_1 to P_2V_2.

Heat absorbs by the system

$\boxed{(dQ)_T = nRT \log \frac{V_2}{V_1}}$

$= nRT \log P_1/P_2$

③ Adiabatic change :- In adiabatic Process. the system neither absorbs energy nor ejectenergy

So $dQ = 0 = dU + dW$

$\therefore \boxed{dU = -dW}$

④ Isobaric Process :- In this Process pressure of the system remains constant

1st law of thermodynamics is

$(dQ)_P = dU + P dV$

or, $n C_P dT = n C_V dT + P dV$

$n dT (C_P - C_V) = nR dT$

$\Rightarrow \boxed{C_P - C_V = R}$